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ABSTRACT

The quality of World Wide Web-based learning depends on several critical success factors. In particular, course materials on the Web should not represent a one-to-one transfer of written lecture notes; added values (e.g., interaction and dialogue components, training modules) should be provided. This paper introduces the approach of multimedia Web-based teachware packages taking these demands into consideration. Applications are based on a series of modular reusable components providing core functionalities--especially flexible navigational guidance--and serving as a framework for developing Web-based teachware packages with any type of content. The first section discusses motivation, including advantages of Web-based learning compared to traditional computer-based training, and a project to create a "virtual campus," at the University of Erlangen-Nuremberg (Germany). A framework for Web-based teachware packages is presented in the second section, including flexible navigational guides, orientation guides, interactive components, annotations, glossary, online manual, assistance by the tutor and technical support staff, and learner-learner communication. The third section addresses reusability and course generation, including integrated guided tour definition and separated guided tour definition. Figures illustrate the control panel, navigational guides, and separated guided tour definition. (AEF)

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A Framework for WWW-based Learning with Flexible Navigational Guidance

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Abstract: The quality of WWW-based learning depends on several critical success factors. Especially, the course materials on the WWW should not represent a one to one transfer of written lecture notes. Added values like interaction and dialogue components, training modules, etc. should be provided. This paper introduces the approach of the multimedia WWW-based teachware packages taking these demands into consideration. Applications are based on a series of modular reusable components providing core functionalities - especially flexible navigational guidance - and serving as a framework for developing WWW-based teachware packages with any type of content.

1 Motivation

WWW-based learning can offer a variety of interesting advantages compared to traditional Computer Based Training (CBT). Among others these include the inherently effortless distribution of learning materials combined with the ease of promptly updating courses and the possibility of simply reusing existing lecture content in a new context as well as many possibilities of collaborative learning within the network. To fully utilize the conceivable potential a few constraints, specific to WWW-based learning, need to be taken into consideration.
At the University of Erlangen-Nuremberg, which is spread out over an area of about 500 km^2, a project to create a "virtual campus", providing a new type of network based learning experience is currently being run. Part of this undertaking is to create a supported, open environment for teaching, learning and co-operation, which provides students with multimedia WWW-based teachware packages on various subjects. This work, which is being pursued as part of a teleteaching/telelearning project [Bodendorf, Grebner & Langenbach 1997], focuses on critical success factors of WWW-based learning. WWW-based teachware packages are integrated in the curriculum of students at the Faculty of Economics and Social Sciences. They encourage a self motivated acquisition of basic knowledge, which is then further refined during face-to-face lectures, tutorials and seminars.

2 A Framework for WWW-based Teachware Packages

Multimedia WWW-based teachware packages are implemented entirely in HTML, Java, JavaScript and WWW-compatible media formats, with no CGI processes taking place. This provides the means for online use on the Inter- and Intranet but also allows for offline use via CD-ROM. The only prerequisite for the use of the teachware packages is a Java-compatible browser as a front end, with no additional applications or plug-ins which need to be installed and configured.
The teachware packages are based on a series of modular reusable components, which were developed in the first stages of the project to provide core functionalities and to serve as a framework for developing WWW-based teachware packages with any type of content. The learner can make use of this framework functionality in form of a *control panel* (see [Fig. 1]) implemented in Java, where different buttons are dynamically enabled or disabled depending on the context of the information being displayed.
The browser window is subdivided into two frames. The presentation of course materials in the main frame (*information frame*) is managed through the control panel situated in the *control frame*. In addition to navigational guides the framework offers a variety of other functionalities to the user via the control panel. The corresponding components providing these functionalities are outlined below.

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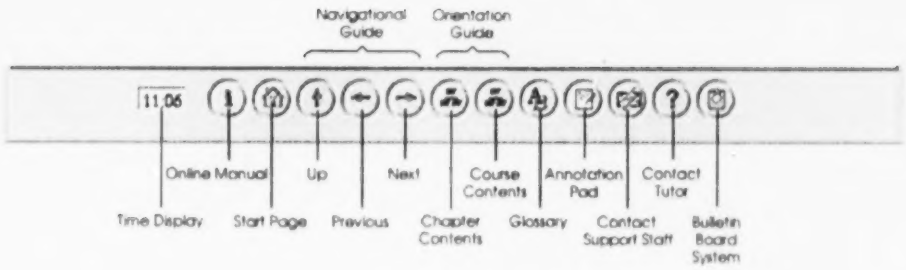

Figure 1: Control Panel

2.1 Flexible Navigational Guides

Navigation through the course materials, which are arranged in a hierarchical way, is supported through the control panel Java applet with its three buttons *up*, *next* and *previous*, the latter offering a specific and context related functionality.

In principle the course content may be experienced in two ways: first through unstructured exploration, looking at table of contents, overview pages and by following links to more information within the teachware package (*user determined presentation*), or second by using the *next* button to follow a predefined guided tour step by step (*system determined presentation*). In the context of this second approach the *previous* button allows the user to go back one step on the guided tour, whereas the *up* button brings the user to the root of the hierarchically preceding course module. If the user initially decides to use the system determined presentation, but leaves the predefined path, for instance to follow links and cross-references to supplementary external resources on the WWW (*composite type presentation*), he or she can always return to the last viewed chapter of the online course by using the *previous* button.

[Fig. 2] shows a schematic representation of the functionality of the navigational guides within a composite type presentation.

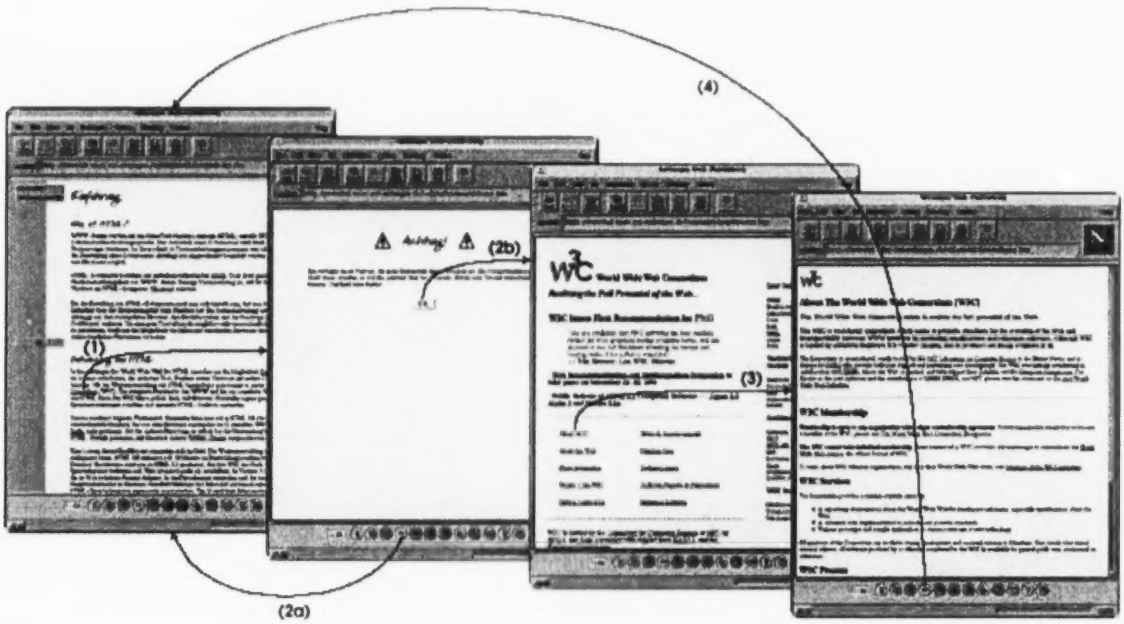

Figure 2: Navigational Guides

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If the learner selects a link to an external source of information on the WWW, the system signals that he or she is about to leave the guided tour of the teachware package (1). At this point the user has the option to return to the guided tour by pressing the *previous* button (2a), or to follow the external link (2b), which is then loaded from the WWW into the information frame without relinquishing the functionality of the control panel which is preserved in the adjacent frame. Within the external sources of information on the WWW the user can follow any other links (3). By using the *previous* button he or she can always directly return to the last chapter within the guided tour of the teachware package (4), without having to use browser specific aides, such as multiple clicks on the "back" button.
This functionality is available in all situations, open to a departure from the predetermined guided tour, i. e. when looking up terms in the glossary or when consulting the online manual.

2.2 Orientation Guides

Within a multimedia WWW-based teachware package essentially two methods are used as an orientation guide. First a *colour coding* is applied to the course materials and second dynamically updated *tables of contents* for the individual chapter and the whole course can be switched on and off in a separate frame by using two corresponding buttons on the control panel. This approach enables the learner to always easily determine his or her exact position within the course without leaving the guided tour.

2.3 Interactive Components

In order to offer the learner interactive components as in standard progression tests a building block was developed in Java, which provides a simple definition of *free form and multiple choice questions and answers* to be integrated into the WWW-based teachware package.
Additionally the fundamental constructivistic requirement for *situation and context oriented learning* [Reinmann-Rothmeier & Mandl 1997] is fulfilled by providing interaction modules for specific areas of the course, where the learner can immediately apply the acquired knowledge to solve an authentic problem. For a HTML course for instance a JavaScript-based HTML test editor was developed, which allows the interactive creation and illustration of HTML documents, for example as a task within a case study, to fully apprehend the course material.
The interactive components are, in contrast to the other program modules introduced here, not accessible via the control panel, but through corresponding buttons within the course context of individual chapters.

2.4 Annotations

An *annotation pad* gives the learner the opportunity to take individual notes on each chapter, which can also be accessed out of context during a subsequent session with the corresponding teachware package.

2.5 Glossary

The *glossary*, which is subdivided into three levels, is always available to access definitions of unclear terms without having to go through any search procedures. Additional external resources from the WWW are easily linked if needed. For an in depth study of sources and literature in support of a specific area of interest, one could imagine an interface to an electronic library.

2.6 Online Manual

An integrated *online manual* is provided to help the user with regard to application specific questions, the functionality of the provided course modules as well as the available communication channels with the tutor,

the technical support staff and other learners. By optionally opening another browser window, the online manual can be used in parallel to the teachware package.

2.7 Assistance by the Tutor and Technical Support Staff

During the online use of a teachware package in a distributed network based teaching and learning environment the learner must always be able to *contact a tutor and the supporting technical staff* through integrated media channels [Graesel, Bruhn, Mandl & Fischer 1996]. This allows the learner to receive help and to jointly find solutions to content related problems and technical as well as ergonomical difficulties. Some interfaces for this type of feedback and interaction have been already tied into the teachware package - reachable via the control panel - to use WWW-based synchronous and asynchronous communication tools, while the integration of others is anticipated. These mechanisms for interaction range from pre-addressed email forms over bulletin boards and whiteboard tools to shared application and videoconferencing systems.

2.8 Learner-Learner Communication

The *multilateral communication* among geographically distributed learners in an online course is also realized. One of the tools already provided is a multimedia WWW-based bulletin board system. In this forum for asynchronous discussion the tutor can create closed user groups, within which learners can jointly solve problems without the feeling of being observed by a third party. An additional feature of the system is its support for multimedia elements, for instance recorded audio contributions or video clips, which permits asynchronous communication not only on a textual level.

3 Reusability and Course Generation

The framework consisting of the program modules outlined above can be filled with multimedia course materials on any topic. At our university teaching materials which are produced within in a variety of other teleteaching and telelearning applications are frequently (re)used in the WWW-based teachware packages. These teaching materials consist of excerpts from lecture video recordings, corresponding digitized blackboard snapshots and overhead transparencies, as well as of contents from multimedia presentations, electronic lecture notes, excerpts from the course textbooks, exercises, etc. In addition, computer animations, textual, visual and audio components are added and external supplementary WWW resources are linked.
The integration of these elements does not require any changes to Java or JavaScript program code. Hence, the respective course author's tasks only include the subdivision of available electronic learning materials into suitable course modules and the integration of the materials into HTML documents, as well as linking the contents of the course to the supporting components outlined above, taking into account their specific advantages (i. e. navigational guidance, possibility of annotation, progression tests etc.) within the respective teachware package.
The guided tour within a teachware package can be laid out using two different methods. Both approaches described here do not rely on any CGI techniques and server interactions which are for instance used in [Goldberg, Salari & Swoboda 1996], [Kutschera 1996] and [Hauck 1996]. By determining the guided tour through a client-based Java/JavaScript approach one can realize a better performance. In addition, the teachware packages can be optionally distributed on CD-ROM and used offline since all the necessary information for the navigational guides can be accessed using the file protocol.

3.1 Integrated Guided Tour Definition

Within this approach, the initialization of the buttons *next*, *previous* and *up* in the control panel is achieved through a JavaScript instruction, individually on every HTML page. Each of these simple instructions merely contains information about the URL (Uniform Resource Locator) being assigned to each button for navigating

back, forward or up within the guided tour and hence does not require any programming skills of the course author. When loading the document the JavaScript instructions are executed and through the Java-JavaScript communication the navigation buttons of the control panel Java applet are initialized by the corresponding method calls. If the learner in an online environment leaves the guided tour to freely explore external sources of information, the *previous* button is dynamically assigned the URL of the last page visited within the guided tour
whereas the *next* and *up* buttons are being disabled.
The approach of the *integrated guided tour definition* described here can only be realized if the course author has access to the HTML documents that are to be displayed as part of the guided tour to add the corresponding initialization instructions to the pages. Additional external resources on the WWW can be *linked* and explored freely by the user leaving the guided tour, with the possibility to directly return to the last viewed chapter of the guided tour anytime using the *previous* button as described above. An integration of external WWW resources *into* the guided tour of the course is not feasible using this approach.

3.2 Separated Guided Tour Definition

An increased range of possibilities is created through the concept of a *separated guided tour definition.* Characteristic of this approach is the separation of HTML documents containing the course material and the meta information defining the guided tour. The course author hence is in a position to create an online course using any teaching materials available on the WWW, whether these are produced internally or externally, supported by the functionality of the navigational guides as described above. Only an common text editor is required for the course author to define the intended guided tour of the teachware package, by sequentially listing all URLs of the pages that are to be part of the course. The hierarchical layer *n* of the individual course modules within the planned teachware package is declared in this list, simply by prefixing a [L*n*]-tag to each URL. [Fig. 3] shows a simple example of a separated guided tour definition for a teachware package on "Internet and WWW".

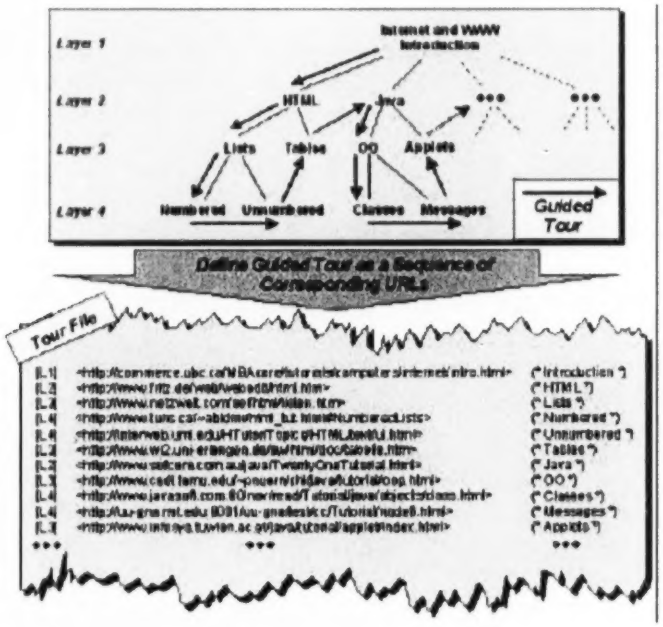

Figure 3: Separated Guided Tour Definition

This URL list - stored in a so-called *tour file* - is used by the navigation applet as a meta information to dynamically initialize the navigational buttons in the control panel. The assignment process is as follows:

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- While loading a document from the teachware package the tour file is searched for this actual URL.
- If an entry is found the *previous* button is assigned the URL of the line directly above this entry and the *next* button is given the value of the URL of the following line.
- In order to initialize the *up* button, the URL of the line with the next lowest *n* in the [L*n*]-tag is used.

Once the learner leaves the predefined guided tour to explore additional external information on the WWW the navigational applet will not be able to find this new URL on the list. In this case, analogous to the integrated guided tour definition, the *previous* button is assigned the last viewed URL within the guided tour of the teachware package and the *next* and *up* buttons are disabled (see [Integrated Tour Definition]).
The concept of a separated guided tour definition does not require any changes to the source of individual course chapters, in contrast to the integrated guided tour definition. This particularly facilitates the task of changing the guided tour by adding, removing or reorganising the course content. Since course materials and meta information are separated, these changes only need to be applied to the tour file described above. In addition, through this approach the course documents can be referenced and used in the tour files of any online courses. Furthermore, any available WWW resources can be integrated into the guided tour of a teachware package. Hence, the requirement of multiple reusability of existing WWW-based teaching modules can be fulfilled in a very easy way.

4 Conclusions and Outlook

The positive feedback to this prototype framework for multimedia WWW-based teachware packages - award winning in this year's software competition of the German Academic Software Co-operation - encourages an extended evaluation beyond the boundaries of our university. An evaluation of the packages is planned at several German and Austrian universities and colleges, as well as in companies and in the area of teacher training. The interest shown by companies and non-university institutions suggests that multimedia WWW-based teachware packages may not only offer a suitable medium for WWW-based learning in higher education, but also a means for knowledge transfer between universities and business.
The development of additional reusable components for multimedia WWW-based teachware packages is planned. Particular emphasis will be placed on the development of Java-based interactive components as well as on an extended navigational support with graphical overviews and an adaptive approach.

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